of leafhoppers, apply just as well to their other enemies. For instance he says (p. 32) of the genus *Reduviolus* of the Heteroptera, I "believe them to be one of the principal agencies in keeping the leafhoppers in check." Why does he not say the Heteroptera are of no importance as enemies of leafhoppers because only a small proportion of the species have been observed to attack them? This argument would be by no means so far fetched as that relating to birds on p. 23, namely, that as leafhoppers were found in only 170 stomachs out of 47,000 examined, birds " very properly may be considered as negligible in any consideration of the natural agencies of control."

Osborn's further remarks that "it is useless to depend on birds for control of these insects. No amount of 'encouragement for the birds' or efforts to utilize their service in this direction can be expected to have any appreciable effect in reducing the number of leafhoppers, and we may dismiss this idea and turn our attention to other more hopeful agencies," are futile and gratuitous. This relation of enemies to prey is true not only of birds but of all natural enemies under natural conditions. It has been possible only in a very few cases to use any kind of natural enemies with striking success and as for control, it has never been accomplished except for limited areas by methods such as are now used in the distribution of the ladybird *Hippodamia convergens* by the California Board of Horticulture.

Some find it difficult to accept the inevitable truths regarding natural enemies, but happily extravagant claims for this enemy or condemnation of that, are largely disappearing from modern publications. All natural enemies should be given credit for useful tendencies, and their protection urged, but the fact must never be obscured that to obtain the degree of control necessary to commercial success, man must practically invariably depend upon direct suppressive measures of his own devising.— W. L. M.

Economic Ornithology in California.— Mr. Harold C. Bryant, who is working as a fellow in applied zoölogy on the State Fish and Game Commission foundation in the University of California, is devoting his attention to problems in economic ornithology. With Professor F. E. L. Beal's comprehensive work, embodied in Biological Survey Bulletins 30 and 34, as a general treatment of the subject and with intelligently directed local work such as Mr. Bryant is doing, to fill in the details, the economic ornithology of California will be better understood than that of any other state. Mr. Bryant has already published several papers dealing with his investigations, three of which are here reviewed.

The economic status of the Meadowlark in California, has for some years been a burning question and naturally this problem has occupied much of Mr. Bryant's time. He has recently published a preliminary paper on the subject.[1] Ranchers in the San Joaquin and Sacramento Valleys report the loss of from one-third to one-half of their grain crops

[1] Monthly Bull. State Comm. Hort. I. No. 6, May, 1912, pp. 226–231.

due to the depredations of meadowlarks on the sprouting seed. It is no wonder therefore that bills removing protection from the bird have been introduced and strenuously supported in the State legislature. Mr. Bryant's investigations justify the charges of injury to grain, but also show that as a destroyer of cutworms and grasshoppers, the meadowlark is probably unequalled by any other California bird. Thus the bird feeds upon grain pests, and clearly does a great deal to offset the direct damage it commits. Whether the bird fully pays for the grain it destroys, can only be determined when the investigation is completed.

The second paper deals with "The present and future status of the California Valley Quail."[1] While the whole paper may be considered economic ornithology in a broad sense, it does not treat the food habits in a detailed way. Mr. Bryant discusses chiefly the decrease of the bird due to hunting, and methods of preserving it in normal numbers, including recommendations on the amount of shooting that may be allowed.

The reviewer finds himself unable to agree with Mr. Bryant's statement that "Food supply is probably, in the last analysis, the most important of the factors governing numbers under natural conditions," at least with reference to species such as Quail which can if necessary live wholly upon seeds and browse. It is admitted of course that the food supply would set a definite limit did species increase up to the point of exhausting it, but normally seed-eating birds as a whole seem to come nowhere near that point. There are always tons upon tons of seeds left to decay after the requirements of all seed eaters, and of reproduction of the plants themselves are satisfied. Lack of versatility in foraging, or idiosyncrasies as to the time or place of feeding, or as to the nature of the food, may at times tend to check the increase of a species. In the East cases are recorded, and they were especially numerous about Washington last winter, in which snow-bound Quail have started to death in sheltered places, when plenty of food could be had for the searching. It is true that these deaths may have been due solely to severe and unaccustomed cold, and if this is true, it opposes the familiar argument that abundance of food is sufficient protection against freezing.

In a third paper entitled "Birds in Relation to a Grasshopper Outbreak in California,"[2] Mr. Bryant says: "Certain sections of California are annually troubled with grasshoppers, and there is seldom a year when they do not cause considerable damage in some part of the State. . . Reports of damage caused by grasshoppers in 1912 first began to appear in June. The western part of Merced County, and parts of Kings and Kern Counties, were most affected. The present investigation was largely carried on in the vicinity of Los Banos, Merced County, this being one of the worst centers of infestation." (p. 3). . . "Little damage could be noted where the grasshoppers were less than fifteen to the square yard. Where damage was

[1] Condor, XIV., July, 1912, pp. 131–142.
[2] Univ. Calif. Publ. Zool., Vol. 11, No. 1, Nov. 1, 1912

greatest, alfalfa fields averaged about twenty-five to the square yard. In some pasture land along the canals, the numbers were estimated at thirty per square yard."

"Los Banos, largely on account of its great irrigation system and the large amount of land which has been swamped, supports a very large bird population. Water-birds and shore-birds are very abundant along the canals and in the marshes, whereas the pasture lands, alfalfa and the trees, furnish food and cover for many land birds. During the week's stay, July 10 to 17, 1912, twenty-two species of water- and shore-birds were recorded, and forty species of land birds." (p. 4.)

"Blackbirds, kingbirds, shrikes, and meadowlarks appeared to be feeding almost wholly upon grasshoppers, and so must be considered among the most efficient destroyers of these insects. Kingbirds and shrikes, better known as butcherbirds, were constantly seen to catch a grasshopper, carry it to the telephone wires, beat it to pieces, and eat it. The work of these birds and also of blackbirds and orioles was so evident that several ranchers reported these birds as being beneficial in the destruction of grasshoppers." (p. 7.)

"Only a few birds of each species were examined, but even these small numbers should give a fairly accurate idea of the extent to which birds in the infested areas were feeding on grasshoppers."... "The burrowing owl must be considered the most efficient destroyer, since parts of twenty-eight grasshoppers were found in the one stomach examined. Blackbirds and meadowlarks, however, because of the large numbers of individuals, were doing the most effective work." (pp. 7–8.)

The total number of grasshoppers daily destroyed by the entire bird population per square mile in the infested area, is estimated at 120,445, and Mr. Bryant adds: "Emphasis can well be placed on the fact that a diminution of the numbers of an injurious insect must cause a corresponding diminution of the damage done. If twenty grasshoppers are causing damage on a square yard of alfalfa the loss of even two must cause some diminution in the amount of damage done, however slight it may be. Consequently the large numbers of grasshoppers taken by birds during the outbreak must have meant a decrease in the possible damage in spite of the fact that such a decrease could not be noted." (pp. 16–17.)

Possibly this conclusion is accurate with regard to injury by grasshoppers, but it is obvious that it is not widely applicable to the reduction of damage by the destruction of insect pests by their natural enemies. For instance after even a high percentage of such pests as the plum curculio, codling moth, nut-weevils and the like, are destroyed, if the survivors thoroughly distribute their eggs, the damage to the crop will be as great as before, since one larva in a fruit as effectually ruins it for marketing as would several. It may further be remarked with reference to Mr. Bryant's statement that a decrease in damage which cannot be noted is not commercially significant.

The author's conclusions, in the main are very conservative: "Since

the time of the Mission fathers," he says, "when grasshoppers were first recorded as giving trouble, these insects have continued their ravages. The bird population during that time has undergone a considerable change. Certain water- and shore-birds, many of them known to be efficient grasshopper destroyers, and especially important because of their migratory habits, have been greatly reduced in numbers. On the other hand certain land birds, owing to a better food supply and cover, have increased in number. Perhaps the most notable example of this increase is to be found in the meadowlark, a bird which feeds almost entirely on grasshoppers when they are abundant. It seems reasonable to believe that the increase of birds has in part, at least, paralleled whatever increase of grasshoppers may have been due to the increased food supply furnished by man. But in spite of what the birds have accomplished in the destruction of these insects, they continue to give trouble. Consequently we should not be justified in saying that birds are capable of controlling all grasshopper plagues so as to prevent damage." (p. 13.)

"The average number of grasshoppers, when in normal numbers, per square yard probably does not exceed two or three, and as a rule is probably less. The bird population, though taking but a tenth as many grasshoppers at such a time, would be taking a far greater percentage of the total number of these insects than when taking the numbers found to be consumed during the outbreak. A smaller number of grasshoppers destroyed at the time of minimum numbers has a more important bearing on the prevention of an increase than a larger number destroyed at the time of maximum numbers. We can safely infer, therefore, that the regulative influence of birds is just as important throughout the year as during an insect outbreak, or even more important." (p. 16.) This conclusion agrees with that reached by Professor F. E. L. Beal, from a lifetime's work in economic ornithology. (See Yearbook U. S. Dept. Agr. 1908, pp. 343–350.)

However, Mr. Bryant's researches give proof of what has been questioned by some, namely that birds increase in numbers in areas severely infested by some insect pest, and that they vary their diet to include an abnormal proportion of the over-abundant species. "The investigation showed that the birds in the vicinity of the outbreaks changed their food habits, in that they fed on the insect most available. The fact that meadowlarks neglected their usual percentage of ground beetles and fed almost entirely on grasshoppers can be explained in two ways. Either the grasshoppers were taken in preference, or they were taken because they were the most easily obtained. The large number eaten by the killdeer, and by the Anthony green heron, horned lark, and oriole demonstrates this point, for the recorded food of these birds under other conditions does not show so large a percentage of grasshoppers."

"Undoubtedly birds flocked to the infested areas. Brewer blackbirds were seen flying out from the ranch houses to the infested areas to feed. Large flocks of bicolored red-wings fed almost entirely in the areas where grasshoppers were abundant. A census of birds taken in infested areas,

compared with one taken in a non-infested district, showed birds to be about three times as abundant in the infested areas during hours of feeding." (p. 17.)

"The failure of birds to check an insect outbreak is evident to all. Their success in preventing insects from becoming abnormally abundant is not so apparent but is no less real. All obtainable evidence, however, points to the fact that the regulative influence exerted by birds when insects are to be found in normal numbers, although less apparent, is none the less important, for at such times artificial control measures are seldom used." (p. 19.)

It is upon the comparative value of artificial control and the activities of natural enemies that the reviewer would make a few remarks. There is a deep-seated, and persistent (because founded on love of ease) idea that if natural enemies are only sufficiently encouraged and protected, crop production free from the annoyance of insect pests will be assured. That this is a dream impossible of fulfillment, is evident from the fundamental interrelations of living things. Natural enemies have developed because there was an excess of individuals of certain species that could be destroyed without any permanent decrease in the numbers of the species as a whole. In creatures with annual or shorter generations as is the case with most insects, all but an exceedingly small proportion of the offspring must die without participating in reproduction; the way of their taking off is unimportant, they may as well be eaten, as to starve, dry up or freeze. Whatever happens to the supernumeraries, a small but fecund minority remains, and the average number of the species is about the same from year to year. If there is an excess of individuals, under natural conditions, that satisfies the demands of enemies, without endangering the existence of the species, what an overwhelming excess of a species there must be where we give over acres or hundreds of acres to pure cultures of its favorite food plants. No wonder there are constantly recurring outbreaks with which natural enemies are unable to keep pace even in a relative way.

As the writer has pointed out elsewhere[1] when we consider the degree of insect control necessary to the commercial success of crops, it is evident that man must almost invariably depend upon his own efforts. We must know about natural enemies, give them all due credit, and protect them, but we must beware of exaggerating their services. People are only too easily misled in this direction but the final result of too great faith in natural enemies is disappointment. Let the student of natural economics see therefore that blame for such disappointment cannot justly be laid upon him.—W. L. M.

Some Bird Enemies of Amphipods.—In an interesting paper[2] covering the general life histories of 4 species of amphipods found about Ithaca,

[1] Yearbook U. S. Dept. Agr., 1911, p. 245.

[2] Sonderabdruck aus Internat. Rev. d. gesamten Hydrobiologie u. Hydrographie. Biol. Suppl. III, 1911 (1912), 33 pp.